

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY

Chains, Rings and Spectroscopy



2814

Monday

23 JANUARY 2006

Morning

1 hour 30 minutes

Candidates answer on the question paper.

Additional materials:

Data Sheet for Chemistry

Scientific calculator

Candidate
Name

Centre
Number

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Candidate
Number

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TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers, in blue or black ink, in the spaces provided on the question paper.
- Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do not write in the bar code. Do not write in the grey area between the pages.
- **DO NOT WRITE IN THE AREA OUTSIDE THE BOX BORDERING EACH PAGE. ANY WRITING IN THIS AREA WILL NOT BE MARKED.**

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- You may use the *Data Sheet for Chemistry*.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE

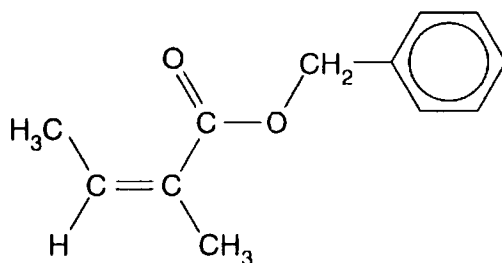
Qu.	Max.	Mark
1	12	
2	14	
3	13	
4	17	
5	10	
6	13	
7	11	
TOTAL	90	

This question paper consists of 16 printed pages.



Answer all the questions.

- 1 Compound A is used to add the flavour of mushrooms to foods.



compound A

- (a) (i) Apart from the benzene ring, name the two functional groups in compound A.

..... [2]

- (ii) Draw the skeletal formula of compound A.

[1]

- (iii) Deduce the molecular formula of compound A.

..... [1]

- (b) Compound B is a stereoisomer of compound A.

Explain what is meant by the term *stereoisomerism*. Use compounds A and B to illustrate your answer.

.....

[2]



- (c) If the food is cooked for a long time, naturally occurring acids catalyse the hydrolysis of compound **A**.

Draw structures to show the **two** organic compounds formed by the acid hydrolysis of compound **A**.

[2]

- (d) The hydrolysis of compound **A** can be monitored by sampling the mixture at regular intervals, separating the components, and recording their infra-red spectra.

- (i) State **two** absorptions that would be expected in the infra-red spectrum of compound **A**, and identify the parts of the molecule responsible for each.

.....
.....
..... [2]

- (ii) Suggest a wavenumber range within the spectrum that could be used to clearly distinguish compound **A** from the products formed by the hydrolysis reaction.

Explain your answer.

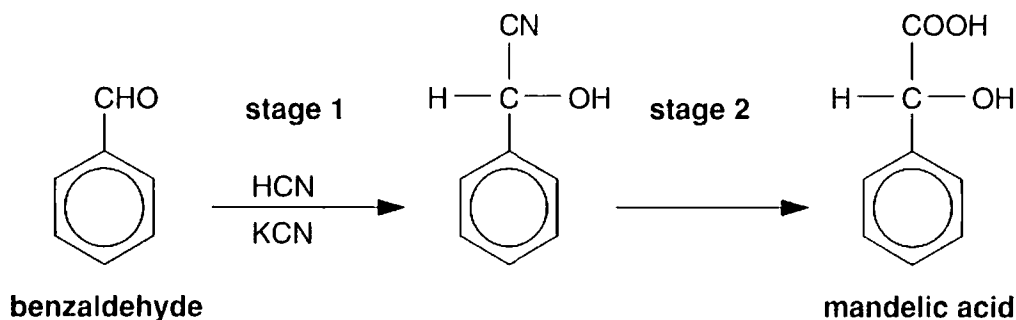
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..... [2]

[Total: 12]

[Turn over]



- 2 Mandelic acid, $\text{C}_6\text{H}_5\text{CH}(\text{OH})\text{COOH}$, is found naturally in almonds. It is the active ingredient in some skin creams that are used to combat signs of ageing. Mandelic acid can be synthesised from benzaldehyde in two stages as shown below.



- (a) (i) Show in detail the mechanism for the reaction in **stage 1**.

[4]

- (ii) State the name of this mechanism.

..... [1]

- (b) Explain why reactions such as that used in **stage 1** are particularly useful in organic synthesis.

..... [1]

- (c) (i) State the reagents and conditions needed to carry out **stage 2**.

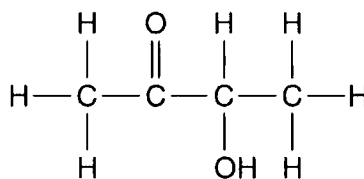
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[illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible]

- 3 *Thua nao* is a traditional sauce made in Northern Thailand by fermenting cooked soybeans. Its unique flavour is due to a range of volatile compounds formed during the fermentation.

One of these volatile compounds is 3-hydroxybutanone.



3-hydroxybutanone

- (a) State the meaning of the term *volatile*.

..... [1]

- (b) Several hydroxyketones with similar boiling points can be separated from the fermentation mixture.

Describe a method, which does **not** involve spectroscopy, that could be used to distinguish 3-hydroxybutanone from the other hydroxyketones.

.....

 [4]

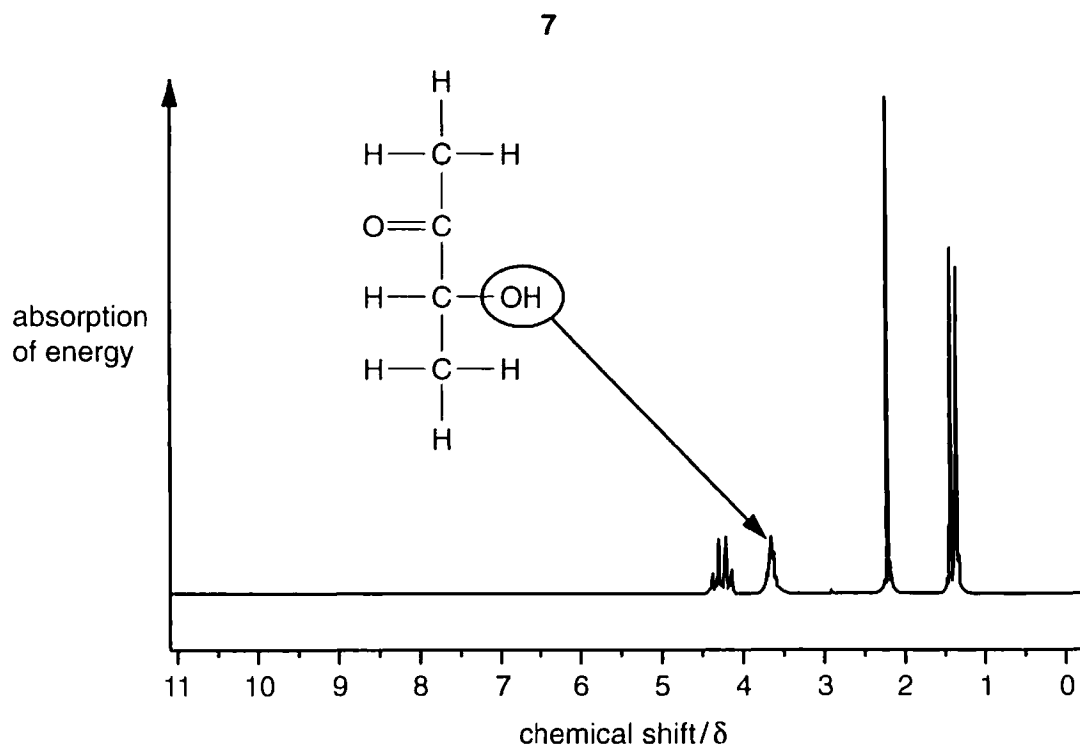
- (c) 3-Hydroxybutanone can also be identified using its n.m.r. spectrum which is shown opposite.

- (i) Use the structure shown on the spectrum to label the parts of the molecule that are responsible for each of the peaks. One has been done for you. [2]
- (ii) Explain how you could confirm that the labelled peak on the spectrum is the hydroxyl peak.

.....

 [2]





n.m.r. spectrum of 3-hydroxybutanone

- (iii) Explain the splitting patterns shown by the peaks at $\delta = 1.4$ and $\delta = 4.3$.

.....

.....

.....

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..... [2]

- (iv) Underneath each of the four peaks on the spectrum above, write the relative peak area expected for that peak. [1]

- (v) What determines the relative area of a peak?

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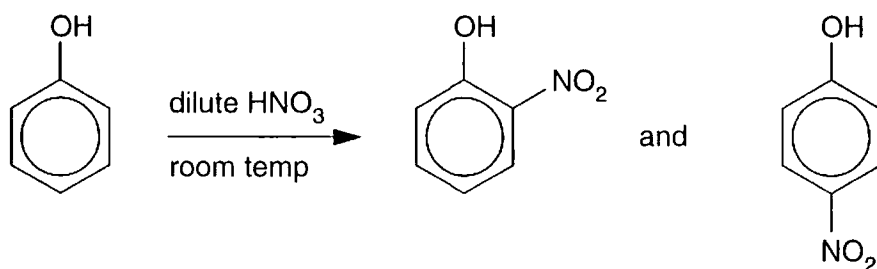
..... [1]

[Total: 13]

[Turn over]



- 4 Phenol reacts readily with dilute nitric acid at room temperature in a nitration reaction to produce a mixture of products as shown below.



- (a) Suggest the structure of another organic product that is likely to be formed in the nitration of phenol.

[1]

- (b) Assuming a yield by mass of 27% for 4-nitrophenol, calculate the mass of 4-nitrophenol that would be produced from 100 g of phenol. Show your working.

Give your answer to an appropriate number of significant figures.

mass of 4-nitrophenol = g

[4]



- State and explain the effect of the -OH group on the reactivity of the benzene ring in phenol.

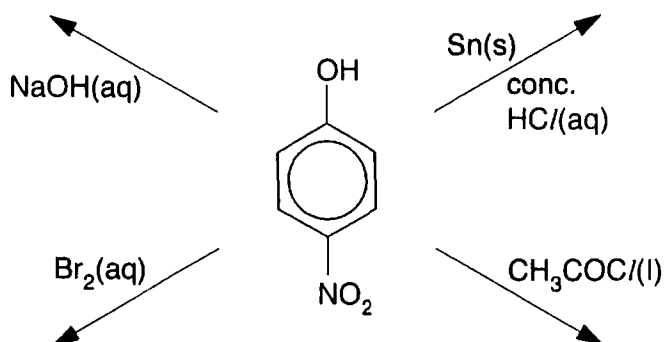
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Quality of Written Communication [1]

[Turn over



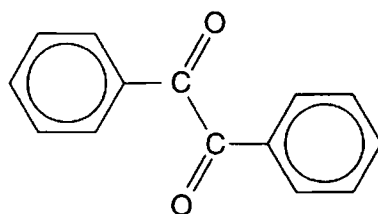
- (d) 4-Nitrophenol can be converted into a range of useful organic chemicals. Draw the structures of the organic products formed in the following reactions.



[4]

[Total: 17]

- 5 The reducing agent, NaBH_4 , is used widely in organic chemistry. One example is for the reduction of diphenylethanedione, $\text{C}_{14}\text{H}_{10}\text{O}_2$, shown below.



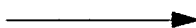
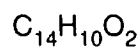
diphenylethanedione

- (a) (i) Draw a displayed formula to show the structure of the organic product that would be formed by reducing diphenylethanedione with excess NaBH_4 .

[1]



- (ii) Complete and balance the equation for this reaction, using [H] to represent the reducing agent.



[1]

- (b) Diphenylethanedione is a pale yellow colour, which disappears when it is reduced.

The colour results from the arrangement of the delocalised π -bond electrons.

Explain what is meant by the term *delocalised π -bond electrons*.

.....
.....
.....
..... [2]

- (c) Coloured organic compounds also include azo dyes.

Describe how an azo dye can be made from phenylamine. Show the structure of the azo dye and the organic intermediate in your answer.

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[6]

[Total: 10]

[Turn over]



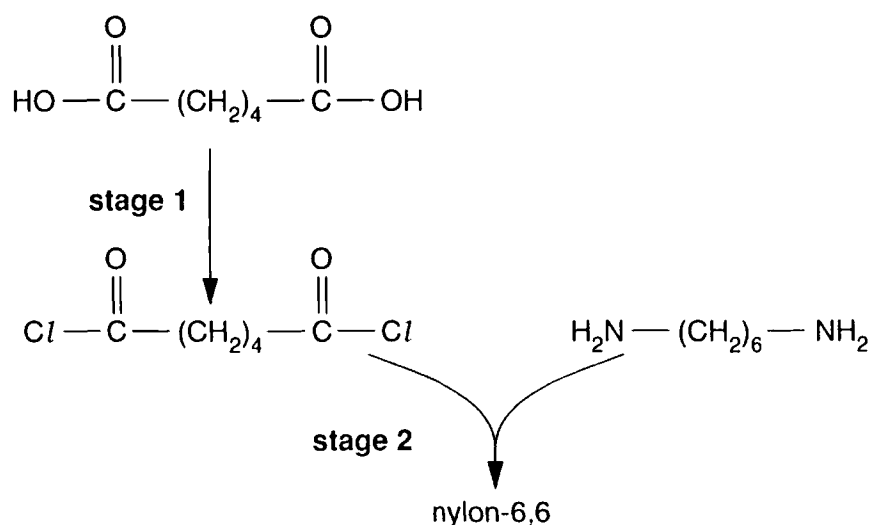
- 6 The fibres used in carpets are made from synthetic or natural polymers such as nylon-6,6, *Orlon*TM and wool.

(a) Complete the table below.

	nylon-6,6	Orlon TM
monomer(s)	$\begin{array}{c} \text{O} \qquad \qquad \text{O} \\ \parallel \qquad \qquad \parallel \\ \text{HO} - \text{C} - (\text{CH}_2)_4 - \text{C} - \text{OH} \\ \\ \text{H}_2\text{N} - (\text{CH}_2)_6 - \text{NH}_2 \end{array}$	
repeat unit of the polymer		$\left[\begin{array}{cc} \text{H} & \text{CN} \\ & \\ -\text{C} & - \text{C}- \\ & \\ \text{H} & \text{H} \end{array} \right]$
type of polymerisation		

[4]

- (b) Nylon-6,6 can be made from its monomers in the laboratory in two stages as shown below.



- (i) State a suitable reagent to carry out **stage 1**.

..... [1]

- (ii) Deduce the inorganic product that is also formed in **stage 2**.

..... [1]



- (c) Industrially, nylon-6,6 is **not** manufactured by the method in (b). Instead, the two monomers are mixed directly at room temperature to give a salt. This salt is then heated to convert it to nylon-6,6.

Suggest the structures of the two ions present in this salt.

[2]

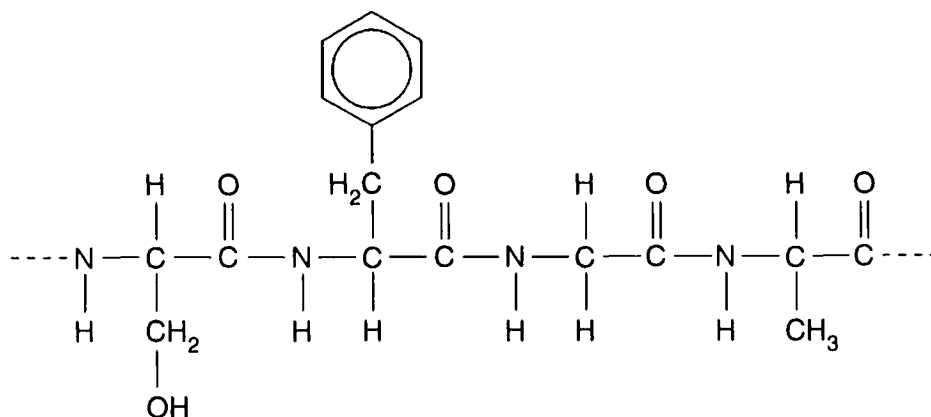
QUESTION 6 CONTINUES ON THE NEXT PAGE

[Turn over



- (d) Wool is a protein. It is a natural polymer made by the same type of polymerisation as nylon-6,6.

A section of the polymer chain in a protein is shown below.



- (i) How many monomer units does this section contain? [1]
- (ii) Draw the structure of **one** of the monomer molecules that was used to form this section.

[1]

- (iii) State **three** ways in which the monomer units of a protein differ from those of nylon-6,6.

.....

.....

.....

.....

..... [3]

[Total: 13]



- 7 (a)** In this question, one mark is available for the quality of use and organisation of technical terms.

Bromine is used in organic chemistry to carry out a variety of electrophilic reactions.

- (i) Describe and explain how a molecule of bromine acts as an electrophile. Illustrate your answer with a diagram showing relevant dipoles and curly arrows.
- (ii) Use your answer to (i) to explain why bromine reacts much more readily with cyclohexene than it does with benzene.

..... [7]

Quality of Written Communication [1]

[Turn over



(b) The compound iodine monobromide, IBr, also reacts with benzene in an electrophilic reaction.

(i) Which compound would be the main product of this reaction, iodobenzene or bromobenzene? Explain your answer.

.....

.....

.....

..... [2]

(ii) Deduce an equation for the reaction of iodine monobromide with benzene.

[1]

[Total: 11]

END OF QUESTION PAPER

Copyright Acknowledgements:

Q.3 n.m.r. spectrum from www.aist.go.jp/RIQDB/SDBS; the Spectral Database Service 10/06/2004.

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